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SOME PINEAPPLE PROBLEMS.

14th ARTICLE. - THE CARBOHYDRATES OF THE LEAF.

By Henry C. Henricksen.

The carbohydrate group includes the sugar, dextrin, starch, gum, mucilage, pectin and cellulose. The origin of these products is the photosynthetic sugar, and the process is reversible. That is, the change from sugar to starch, gum, etc. or vice versa, takes place in the normal leaf, according to the requirements at any time. To what extent certain species may make use of the different forms of cellulose in that respect is not entirely clear. Some investigators assume that any cellulose which may be hydrolysed, into sugar, by heating with 1% hydrochloric acid may also change into sugar in the plant. As there are good reasons for this assumption, it has been adhered to it in this investigation. It is not possible, with present technique, to follow all the changes taking place in the plant. But by determining the products formed at different times and under different conditions it is possible to visualize some of the processes. In the following table the figures are representative of the results of a large number of determinations.

Description	Dry matter %	Total Carbohy. dry mat. %	PER CENT OF TOTAL CARBOHYDRATES.				
			Reducing Sugars Hexoses	Reducing Sugars Pentoses	Inverted Sugars	Non-Sugars Hexoses	Non-Sugars Pentoses
Young leaves from extra vigorous growth	9.3	13	9	4	0	77	10
Young leaves, normal plant	11.8	19	7	4	1	82	6
Mature leaves, normal plant	15	24	16	10	3	61	10
Reddish, leathery leaves from abnormal plant	19.5	30	20	10	1	59	10
Chlorotic leaves. Plant from typical unsuitable soil	14.5	40	21	16	2	46	15

The first column in the table shows an increasing amount of dry matter as the leaves became mature. That is, the young growth is the most watery, which is a well known fact. The leaves of a chlorotic plant form no exception to that rule. They contain a normal amount of water until the age of about twelve months after which they usually dry-up faster than those from normal plants.

The second column shows the total carbohydrates of the leaves that is hydrolysable by 1% hydrochloric acid calculated in per cent of dry matter. That is the total amount of carbohydrates which is supposed to be capable of moving from place to place in the plant, together with that which may change into such form that it can move.

It is readily apparent that this amount increases as the leaves become mature and it is especially noticeable that abnormal plants contain an abnormally large amount; that of the chlorotic leaves being almost double that of the mature leaves from a normal plant.

The third and fourth columns show the reducing sugars, that is the monosaccharide hexoses and pentoses. The amount found in the young leaves is small when computed as per cent of dry matter and as the content of dry matter is small it is readily apparent that very little is present. The mature leaves contain about twice as much hexose sugar as the very young growth, which shows that the change and translocation of sugar in the mature tissue is much slower than it is in the young vigorous tissue. The most significant, however, is the large amount in the leaves from the abnormal plants.

As shown, the reddish, leathery leaves contain 19.5 grams dry matter in each 100 grams fresh leaf tissue of which 30% or 5.85 grams are carbohydrates. Of that amount 20% or 1.17 grams is hexose sugar. In other words each 100 grams fresh leaf tissue contain 1.17 grams hexose sugar. A similar calculation for the chlorotic plants shows that they contain 1.21 grams hexose sugar in each 100 grams fresh material. The mature leaves from the normal plant contain, however, but 0.57 grams, which is less than half of the content of either of the abnormal leaves, showing that the latter is distinctly sugar leaves. Also it shows that reducing sugar and color goes together, for that class of plants is always very red in color.

Of pentose sugars very little is present in the young growth. In the normal mature leaves, the 10% present corresponds to 0.36 grams in each 100 grams fresh tissue. In the chlorotic leaves, of which the pentose content is 16% of the total carbohydrates the corresponding figure is 0.92 grams in each 100 grams fresh material. In other words, the chlorotic leaves contain about three times more pentose sugar than does the normal leaves.

The fifth column shows the inverted sugars, that is the disaccharides changed into reducing sugars by heating with acid. They seem to be present in very small quantities in most samples, but occasionally a mature leaf may contain as high as 6% of the dry matter. That is conceivably due to the fact that at times the starch is changed into maltose faster than the sugar is translocated to the stalk. However, the figures seem not to be significant for the purpose of this investigation.

The sixth column records the non-sugars. They are starch, dextrose, gums, mucilage, pectic substances and such cellulose as is hydrolysable by the acid used. That so large a percent should be found in the young growth, is but natural, for most of the cellulose is yet in a readily hydrolysable condition. In comparing the leaves from the normal plants with those from the chlorotic plants the figures in the table are not very significant. But an examination of the kind of products present reveals differences from which significant conclusions may be drawn. The normal leaves contain a great deal of starch whereas the chlorotic leaves contain barely a

trace. On the other hand the chlorotic leaves contain much mucilagenous products whereas the normal leaves contain but little in comparison. This indicates that starch formation is inhibited in the chlorotic plants notwithstanding that an abundance of sugar, from which starch could be formed, is present, as shown in column three. It does not, however, explain the non-transference of sugar to the stalk. But whatever the reason is, the fact that it is not promptly removed from the place of origin may serve to partly explain the abnormal functioning of the leaf.

The high content of mucilagenous products in the chlorotic leaves causes gum formation whenever the epidermal layers are injured. For instance, it is not unusual to find the sap exuding from the leaf-bases of such plants after having been eaten into by the changa, (mole cricket). Also, it frequently oozes out of the stalk, when that is cut, and solidifies on exposure to the air. This will be referred to again under fruit-maturity for when it appears as an exudation from the fruit it is very troublesome. It does that especially when a prolonged dry period is followed by a wet period and the cause for it may be explained, perhaps, in the following manner: Dry weather induces gum and mucilage formations, these products being beneficial to the plant inasmuch as they help to lessen the loss of water. When rainy weather follows, the tissue that is filled with mucilagenous products will take up a great deal of water and the sap will exude from any abrasion that may be present in the epidermis.

The pentoses recorded in the last column of the table are not sugars like those in column four. They are water-insoluble materials, called pantosans, which are hydrolysed to pentose sugars by boiling with acid. The figures, as they appear, do not show very significant differences but when calculated on the basis of fresh leaf tissue they are more illuminating. The leaves of the normal plant contain 15 grams dry matter in each 100 grams fresh leaf tissue of which 24% or 3.6 grams are carbohydrates, and of those 10% or 0.36 grams are pentoses. That is each 100 grams fresh leaf tissue contain 0.36 grams pentoses or the corresponding amount of pentosans, while that from the chlorotic plant, calculated on the same basis, contain 1.21 grams, or more than three times as much. This is significant in view of the fact that the gums and mucilages contain much pentosan and it confirms the statement of the former paragraph that a great deal of those products are present in the chlorotic plants.